Sicherheit in Technik und Chemie

14.04.2021

Creep Properties of the Refractory Chemically Complex $AlMo_{0.5}NbTa_{0.5}TiZr$ Alloy

Patricia Suárez Ocaño[1], Christian Gadelmeier[2], Uwe Gratzel[2]
Leonardo Agudo Jácome[1]

[1]Bundesanstalt für Materialforschung und -prüfung (BAM), Berlin, Germany.
[2]Metals and Alloys, University Bayreuth, Bayreuth, Germany.

www.bam.de

Introduction
Motivation

Chemically complex alloy
$AlMo_{0.5}NbTa_{0.5}ZrTi$

Deformation mechanism (***tension***) has not been experimentally assessed yet.

ρ= 7.40 g/cm³

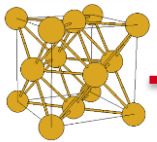
$\sigma_{0.2}$ = 1600 MPa at $T_{800°C}$

$\sigma_{0.2}$ = 745 MPa at $T_{1000°C}$

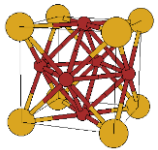
δ RT = 10% , δ HT >50%

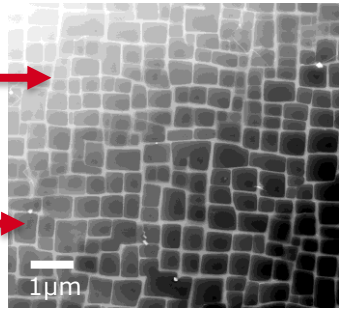
(compression)[1]

Disordered FCC

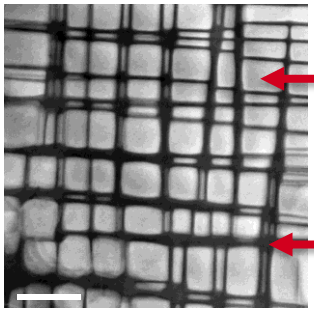


Ordered FCC ($L1_2$)



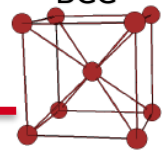


STEM DF micrograph from a Ni-base superalloy (SX).[2]

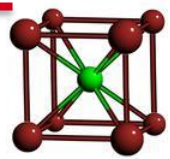


STEM DF micrograph from the CCA (after annealing 1400°C / 24 h)

Disordered BCC



Ordered B2

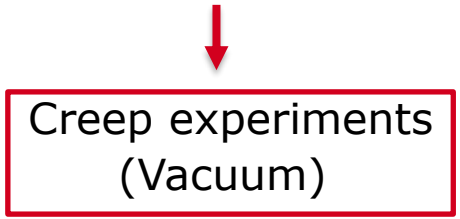


[1] Senkov, et *al.,* Entropy 18, 1–13 (2016).
[2] Agudo Jácome, *et al*. Ultramicroscopy 195 (2018) 157–170

Objective

Evaluate the high temperature performance of the $AlMo_{0.5}NbTa_{0.5}TiZr$ rCCA in terms of determining **mechanisms of mechanical deformation** under relevant application conditions. More specifically:

(1) Evaluate the alloy's **mechanical behavior** under **tension** in the temperature range 800-1000°C.



Creep
Experimental procedure

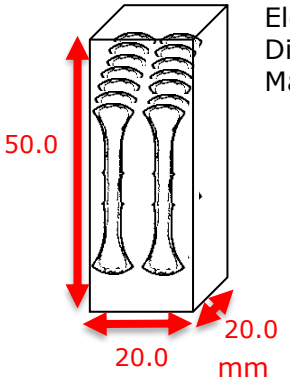
1. Vacuum arc melting (KIT)

Al (at%)	Mo	Nb	Ta	Ti	Zr
19.74	10.12	20.24	10.18	20.15	19.57

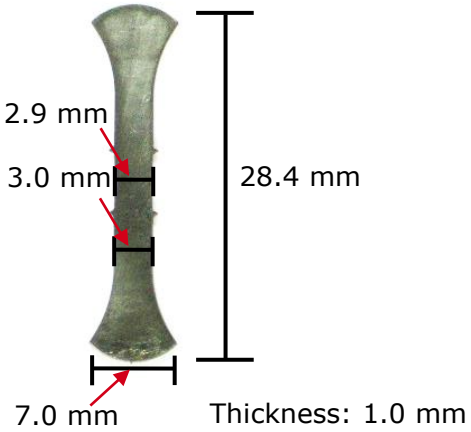
ICP-OES

2. Annealing: 1400 °C for 24 h (KIT)

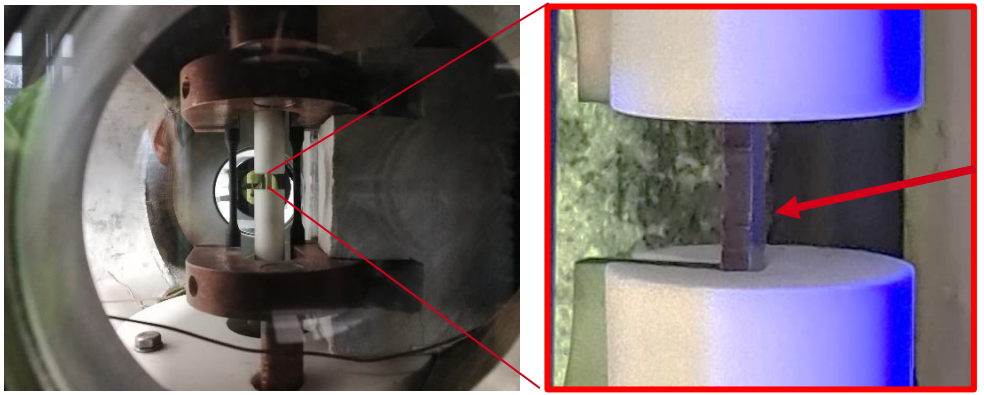
3. HIP: 1370 °C for 4 h, 170 MPa (RUB)



Electric Discharge Machining



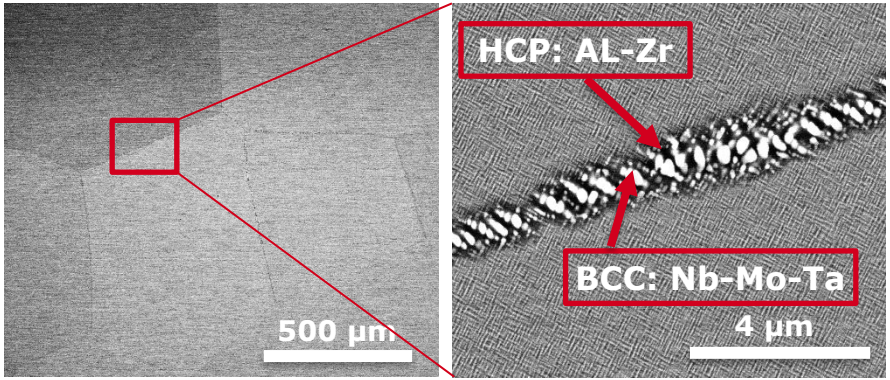
Thickness: 1.0 mm



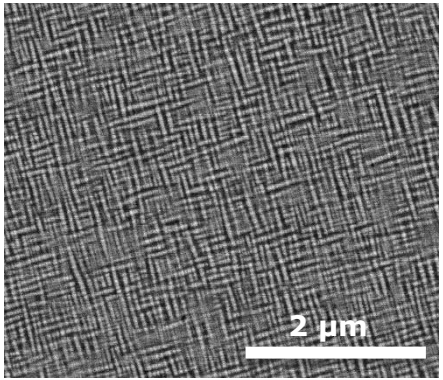
Sample

Vacuum Creep device (10^{-7} mbar). Metals and Alloys, University of Bayreuth.

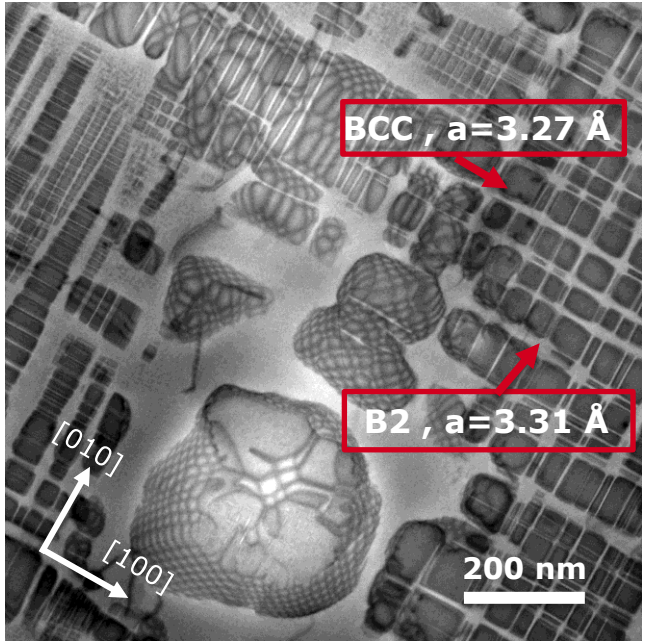
Microstrutural Characterization
CCA $AlMo_{0.5}NbTa_{0.5}TiZr$ before testing



SEM
BSE

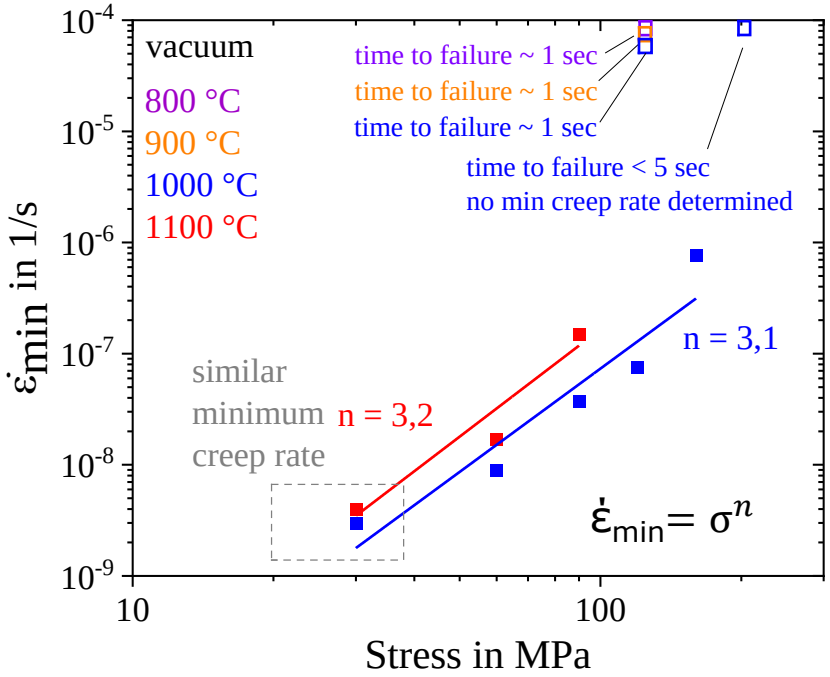


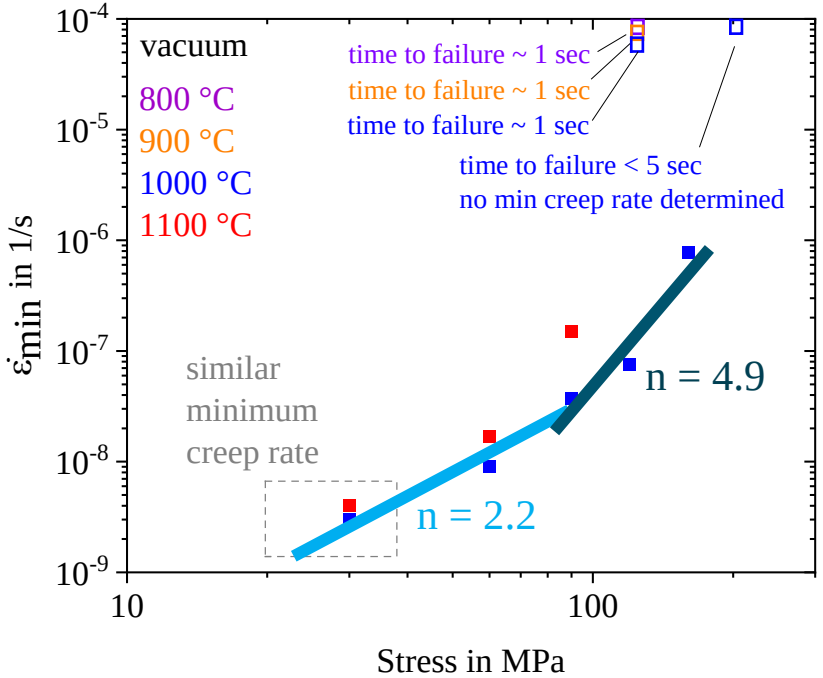
STEMBF



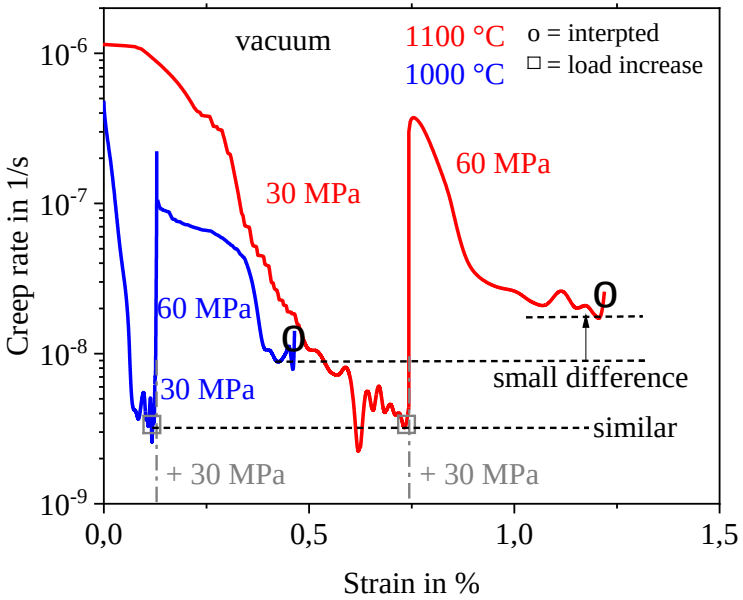
z=[001]

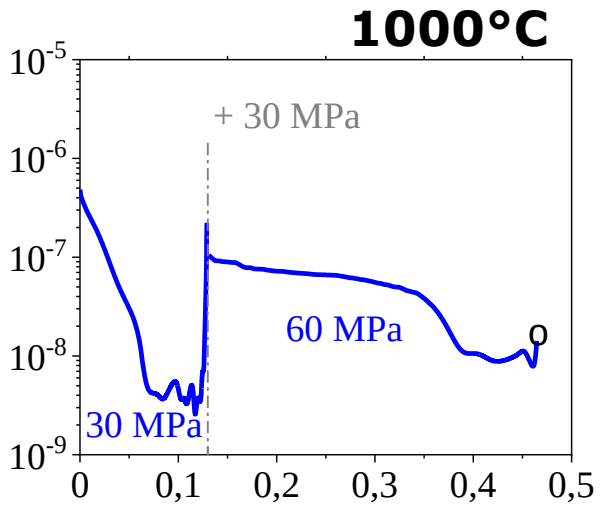
Creep
Norton- Plot





Creep
Results 1000°C and 1100°C

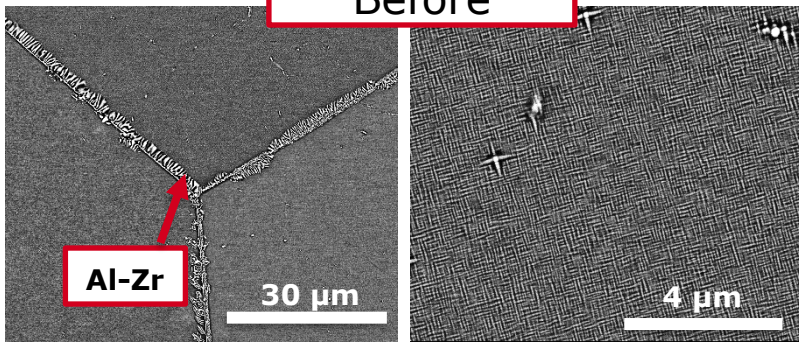




- Not much difference of minimum creep rate at 30 MPa
- Small difference after load increase

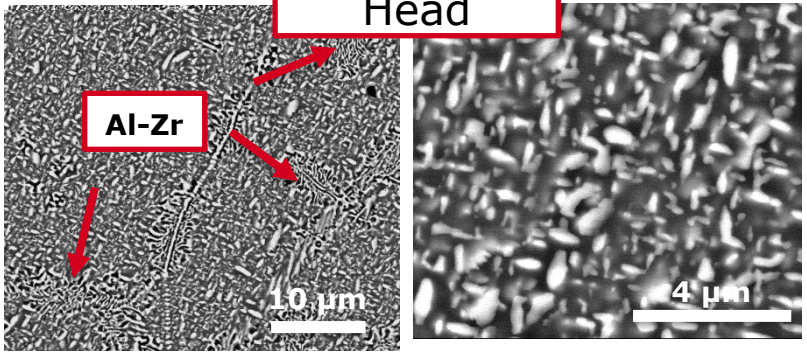
Creep
1100 °C_29-58MPa[1]_1.3%

Before

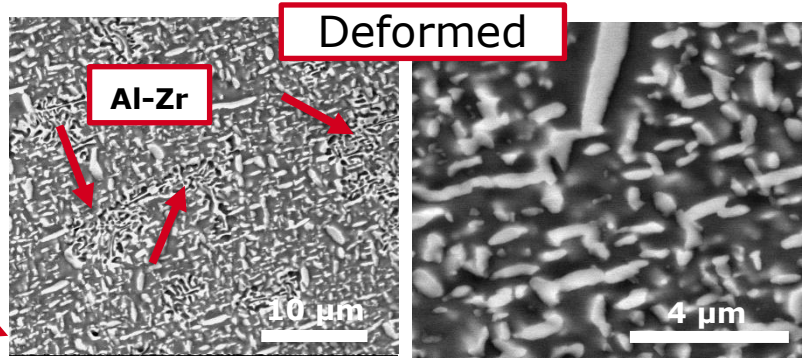


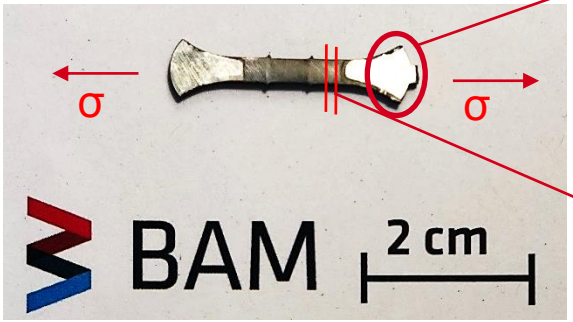
After

Head



Deformed

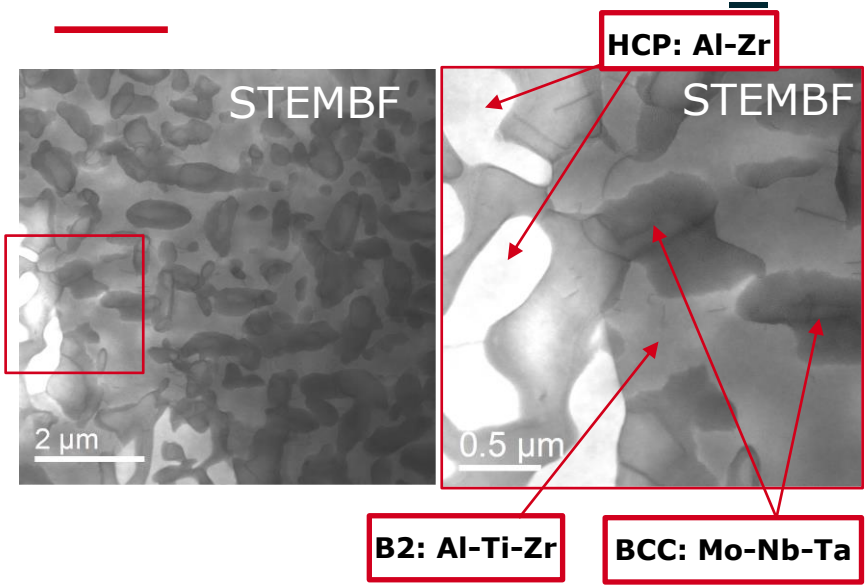


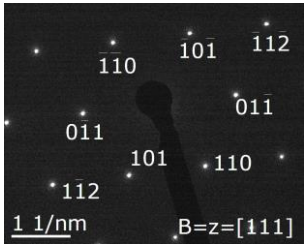


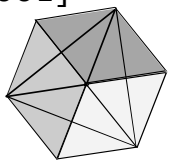
1: A = 3.0 mm² instead of 2.9 mm² outside guides

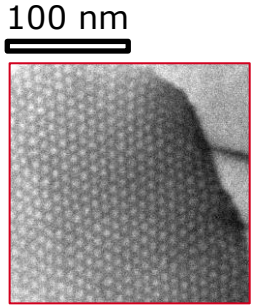
σ

Creep
Microstructure 1100 °C_ 29-58MPa[1]_1.3%

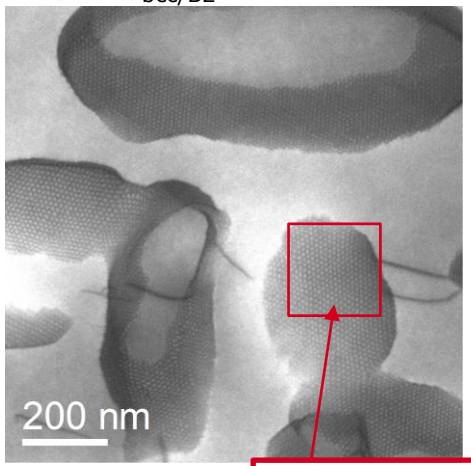


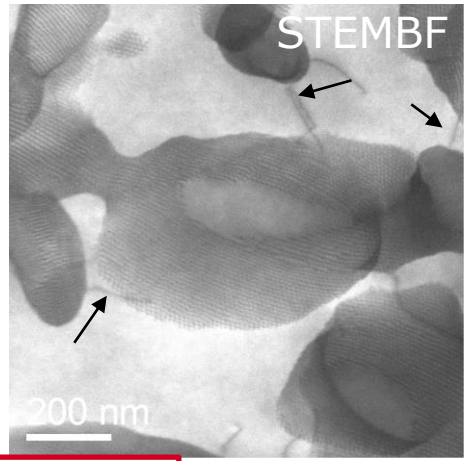






$z=[111]_{bcc/B2}$





Dislocation networks

- coarse and coalesced precipitates of Mo-Nb-Ta
- BCC/B2 fine dislocation networks
- BCC & B2 perfect and super-dislocations
- BCC/HCP eutectic

Summary

For the CCA $AlMo_{0.5}NbTa_{0.5}ZrTi$:

- Creep testing of the $AlMo_{0.5}NbTa_{0.5}ZrTi$ CCA under vacuum was evaluated at different temperatures (excluding oxidation effects).
- Little temperature influence on minimum creep rate @ 1000 and 1100 °C.
- At a first glance, Norton plot shows that deformation is probably both diffusion and dislocation controlled.
- bcc/B2 → Eutectic + and fine dislocation networks present at coarsened bcc/B2 interfaces at HT. Further work needed to stablish deformation and degradation micro mechanisms in the studied creep regime.

Acknowledgments

- Funding: Project n°. 398838389 **DFG**
- Stephan Laube, Dr. Alexander Kaufmann, Prof. Martin Heilmaier, **KIT**
- Prof. Guillaume Laplanche (RUB) Dr. Suzana G. Fries, Dr. Inmaculada López-Galilea, Dr. Benjamin Ruttert, Prof. Werner Theisen, **RUB**
- Dr. Carlos Abad Evgenia Bajer, René Hesse **BAM**